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TITLE: Military Interoperable Digital Hospital Testbed

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**14. ABSTRACT**

The MIDHT project continues to research health information technologies (HIT) within the Conemaugh Health System, located in rural Southwestern Pennsylvania. Core technologies under investigation include electronic health records (EHR), picture archiving and communications system (PACS) and personal health records (PHR).

In summary, studies related to EHR and PACS have both been completed and closed with both the Conemaugh and U.S. Army Institutional Review Boards (IRB). Study experience related to PHRs has resulted in minimal interest and usage by subjects and providers alike. Our findings align with national attitudes of said technology. As the nation focuses on "meaningful use" of EHR systems, wide-spread adoption of PHRs may be 5-10 years away from reality.

**15. SUBJECT TERMS**
Picture Archive and Communication System (PACS), Metabolic Syndrome, Gestational Diabetes, Personal Health Record (PHR), Electronic Health Record (EHR)

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## INTRODUCTION

The Military Interoperable Digital Hospital Testbed (MIDHT) is a five-year program of research to develop a real-world testbed environment in Southwestern Pennsylvania. The purpose is to research and evaluate Health Information Exchange (HIE) and health information technology (HIT) and services that make health information readily available to consumers and providers. Ideally this will allow for the secure transfer of information between private sector rural providers, federal partners and patients. MIDHT has defined requirements and solutions to optimize healthcare resources for rural communities and identified lessons learned and best practices that benefit both the global Military Health System (MHS) environment and stakeholders in the region. The Department of Defense (DoD) and Conemaugh Memorial Medical Center (CMMC) have common requirements for HIE, connecting disparate systems and providers and enabling secure provider-provider and provider-consumer e-communications. Minimal evidence is available on what business, clinical and technical solutions can be used to overcome the lack of specialists, infrastructure and geographical barriers associated with the delivery of care in rural communities.

## BODY

### Arm 1: Longitudinal Study for Use of Interoperable Accessible Health Information Exchange Services and Technologies in Rural Communities (A – 15835.2, A – 16192.1).

This arm focuses on ways a rural environment can capitalize on the use of health information network (HIN) services and technologies to promote interoperability between disparate entities such as TNPs, private sector health systems, and DoD facilities. MIDHT has investigated attitudes, usability, and effectiveness of HIN services by rural providers, including the effect of the use of HIE tools by provider groups, TRICARE providers, and three CHS facilities on their business practices and process flows. Research initiatives have focused on the impact of an electronic health record implementation using instruments utilized in year 1. Additionally, research initiatives evaluated the ability to electronically access digital radiology images and how this system-wide functionality affected the delivery of patient care within a rural health care system, to include an analysis on provider productivity, throughput, duplicative testing and continuity of care. Finally, an assessment of the volume of cases that Conemaugh physicians have with SSA regarding veteran/military disability claims and provider satisfaction with the existing SSA process have been completed.

***Subtask 1.1*** Assess changes in provider workflows and efficiency resulting from the implementation of an ambulatory electronic medical record.

Descriptive Analysis of EHR Survey Results (n=26):

Overall, the staff at Portage and NORCAM indicated an ambivalence regarding satisfaction of the EHR implementation with almost one third stating a neutral satisfaction. When looking at position type, no apparent trends are noted (Note: "Other" most likely includes some physicians). These satisfaction results are much lower than those reported by DesRoches et al regarding a 2008 national survey of physicians on EHR's. Only 34% of CMMC staff is satisfied whereas 90% of physicians surveyed nationally were satisfied. Despite the finding of neutral satisfaction, descriptive analysis of certain questions indicates a positive perception of the EHR. Aggregating the answer choices for question twenty (q0020) as either difficult or easy shows that a majority of respondents indicated the following activities are easier when using the EHR as compared to previous routines:

- Documenting allergies
- Documenting CPT and ICD-9 codes for billing purposes
- Keeping problem lists updated
- Reviewing laboratory and radiology results
- Writing and renewing prescriptions
- Monitoring medication safety during prescribing
- Communicating referral information to specialists

Furthermore, approximately 50% of respondents agree that the EHR has enabled them to accomplish tasks more quickly, has enhanced job effectiveness and made it easier to do their job. Whereas 45% of respondents state they work longer hours to see the same number of patients. Also, no consensus that the EHR has caused disruptions to their workflow was found.

Written comments most often cited suggest that staff appreciate not having to pull and refile paper charts, access to hospital information (e.g. lab/rad results) is much easier (direct interface to Allscripts), and benefits of ePrescribing. On the negative, staff members are frustrated with the multiple screens and not being able to quickly find information, creating clinical notes is too cumbersome, determining which tests were ordered was more difficult and more training is needed.

Although the significance of the following statistical analysis cannot be interpreted as definitive due violations resulting from the sample size, the results due generally support the conclusions drawn from the descriptive analysis above.

Statistical Analysis of EHR Survey Results (n=26):

Crosstabs were performed over questions 1-19 (rows) on questions 22, 27, 28, 29, 30 and 31 (columns). Chi-square was used to test for significance between the columns over the rows. Unfortunately, the sample size (N=26) produced untenable cell counts and significance testing

could not be performed. Furthermore, a crosstab of question 30 and 31 did not produce a significant result using Chi-square; nor did question 22 with 30. Analyzed independently, questions 20 and 21 yielded slightly positive responses, overall. The low sample size overall and decline in responses over time prevented a longitudinal analysis of survey data as designed. Please refer to Appendix 1 for a copy of the survey results.

| | S04_3_q0022 | S04_8_q0027 | S04_9_q0028 | S04_10_q0029 | S04_11_q0030 | S04_12_q0031 |
|---|---|---|---|---|---|---|
| **S02_q0001** | 0.274 | 0.108 | 0.295 | 0.008 | 0.200 | 0.085 |
| **S02_q0002** | 0.063 | 0.568 | 0.615 | 0.032 | 0.511 | 0.005 |
| **S02_q0003** | 0.020 | 0.644 | 0.390 | 0.188 | 0.267 | 0.037 |
| **S02_q0004** | 0.018 | 0.433 | 0.356 | 0.728 | 0.080 | 0.102 |
| **S02_q0005** | 0.011 | 0.719 | 0.347 | 0.739 | 0.817 | 0.012 |
| **S02_q0006** | 0.225 (0.378) | *0.431 ( 0.695)* | 0.018 | 0.743 | 0.027 (0.073) | 0.053 |
| **S02_q0007** | 0.255 | 0.988 | 0.398 | 0.379 | 0.203 | 0.013 |
| **S02_q0008** | 0.320 | 0.486 | 0.378 | 0.389 | 0.037 | 0.094 |
| **S02_q0009** | 0.819 | 0.793 | 0.727 | 0.384 | 0.039 | 0.322 |
| **S02_q0010** | 0.206 | 0.930 | 0.059 | 0.837 | 0.022 | 0.049 |
| **S02_q0011** | 0.161 | 0.550 | 0.223 | 0.753 | 0.759 | 0.567 |
| **S02_q0012** | 0.151 | 0.253 | 0.210 | 0.012 | 0.648 | 0.330 |
| **S03_1_q0013** | 0.030 | 0.136 | 0.511 | 0.185 | 0.626 | 0.169 |
| **S03_2_q0014** | 0.070 | 0.574 | 0.338 | 0.255 | 0.763 | 0.592 |
| **S03_3_q0015** | 0.362 | 0.113 | 0.957 | 0.424 | 0.917 | 0.920 |
| **S03_4_q0016** | 0.332 | 0.756 | 0.966 | 0.238 | 0.799 | 0.691 |
| **S03_5_q0017** | 0.041 | 0.105 | 0.556 | 0.018 | 0.317 | 0.093 |
| **S03_6_q0018** | 0.023 | 0.134 | 0.022 | 0.255 | 0.378 | 0.160 |
| **S03_7_q0019** | 0.229 | 0.596 | 0.055 | 0.753 | 0.039 | 0.133 |

**NOTES:**
1) Values in this table represent the Pearson Chi-square result except where indicated below.
2) ( ) indicate the asymptotic significance as calculated by the Fisher's Exact Test for a 2x2 matrix
3) italics indicate that fewer than 25% of the cells have an expected count < 5
4) All results (except those in italics) result from a matrix that has at least 33% of the cells with an expected count < 5. As such, these results should not be used to make concrete inferences as to significance.

**Table 1. Chi-Square p-values for Crosstabs of Survey Questions**

**Crosstab**

| | | | S04_3_q0022 | | Total |
|---|---|---|---|---|---|
| | | | No | Yes | |
| S04_11_q0030 | No | Count | 5[a] | 13[a] | 18 |
| | | % within S04_3_q0022 | 71.4% | 72.2% | 72.0% |
| | Yes | Count | 2[a] | 5[a] | 7 |
| | | % within S04_3_q0022 | 28.6% | 27.8% | 28.0% |
| Total | | Count | 7 | 18 | 25 |
| | | % within S04_3_q0022 | 100.0% | 100.0% | 100.0% |

Each subscript letter denotes a subset of S04_3_q0022 categories whose column proportions do not differ significantly from each other at the .05 level.

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) |
|---|---|---|---|---|---|
| Pearson Chi-Square | .002[a] | 1 | .968 | | |
| Continuity Correction[b] | .000 | 1 | 1.000 | | |
| Fisher's Exact Test | | | | 1.000 | .663 |
| N of Valid Cases | 25 | | | | |

a. 1 cell (25.0%) has an expected count less than 5. The minimum expected count is 1.96.
b. Computed only for a 2x2 table

**Table 2. Crosstab Results and Chi-Square p-value for Survey Questions 11 and 22**

**Crosstab**

| | | | S04_3_q0022 | | Total |
|---|---|---|---|---|---|
| | | | No | Yes | |
| S04_12_q0031 | DISsatisfied | Count | 4[a] | 2[b] | 6 |
| | | % within S04_3_q0022 | 57.1% | 11.1% | 24.0% |
| | VERY DISsatisfied | Count | 1[a] | 2[a] | 3 |
| | | % within S04_3_q0022 | 14.3% | 11.1% | 12.0% |
| | neutral | Count | 2[a] | 5[a] | 7 |
| | | % within S04_3_q0022 | 28.6% | 27.8% | 28.0% |
| | somewhat satisfied | Count | 0[a] | 8[b] | 8 |
| | | % within S04_3_q0022 | .0% | 44.4% | 32.0% |
| | VERY satisfied | Count | 0[a] | 1[a] | 1 |
| | | % within S04_3_q0022 | .0% | 5.6% | 4.0% |
| Total | | Count | 7 | 18 | 25 |
| | | % within S04_3_q0022 | 100.0% | 100.0% | 100.0% |

Each subscript letter denotes a subset of S04_3_q0022 categories whose column proportions do not differ significantly from each other at the .05 level.

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 7.993[a] | 4 | .092 |
| N of Valid Cases | 25 | | |

a. 8 cells (80.0%) have expected count less than 5. The minimum expected count is .28.

**Table 3. Crosstab Results and Chi-Square p-value for Survey Questions 12 and 22**

**S04_11_q0030 * S04_12_q0031 Crosstabulation**

| | | | S04_12_q0031 | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | DISsatisfied | VERY DISsatisfied | neutral | somewhat satisfied | VERY satisfied | Total |
| S04_11_q0030 | No | Count | $2_a$ | $2_a$ | $7_a$ | $7_a$ | $1_a$ | 19 |
| | | % within S04_12_q0031 | 33.3% | 66.7% | 87.5% | 87.5% | 100.0% | 73.1% |
| | Yes | Count | $4_a$ | $1_a$ | $1_a$ | $1_a$ | $0_a$ | 7 |
| | | % within S04_12_q0031 | 66.7% | 33.3% | 12.5% | 12.5% | .0% | 26.9% |
| Total | | Count | 6 | 3 | 8 | 8 | 1 | 26 |
| | | % within S04_12_q0031 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

Each subscript letter denotes a subset of S04_12_q0031 categories whose column proportions do not differ significantly from each other at the .05 level.

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 6.940[a] | 4 | .139 |
| N of Valid Cases | 26 | | |

a. 8 cells (80.0%) have expected count less than 5. The minimum expected count is .27.

**Table 4. Crosstab Results and Chi-Square p-value for Survey Questions 30 and 31**

Statistical Analysis of Productivity Data (n = 6 providers (control), 5 providers (EHR)):

Initial statistical analysis obviated the necessity for additional data points to achieve sufficient symmetry and homogeneity to produce an analyzable dataset. A protocol modification was necessary to further clarify the time period to be used (January 2007 – February 2010) for analysis, which was approved by Conemaugh IRB on December 9, 2011.

Quarterly data was obtained for years 2007 through 2011. Both a MANOVA and RM-(m)ANOVA were attempted; however, underlying assumptions for those tests were violated. The data was reorganized and recast to conform to a paired-t and a standard independent t-test. Since Year 2007 only contained data for the following variables, Charges, Units, Encounters, and Office Hours Worked, it could not be included in the paired-t or independent t-test derived from the paired-t setup. Furthermore, the calendar quarters for all years were not consistent due to the implementation. To minimize the impact of potential periodicity, the data pairing for the paired-t used 2009, 2010, and 2011 data. The paired-t test was used to investigate the within-group change between the post and pre time periods. Due to the testing of multiple dependent variables, the test-wise alpha was adjusted so that the overall alpha remained 0.05. The following calculated variables were produced so as to provide for a more direct comparison between the control and intervention groups: Charge/Unit, Encounters/Hr, and Total RVUs per Encounters/Hour. The difference (post-pre) was calculated and a standard t-test was applied to test if the mean difference was statistically significant between groups. No statistical significance was found.

Despite the finding of no statistical significance between the control and intervention group, the change (post - pre) in the mean difference of encounters per hour improved for the intervention

group and not the control group (0.28 vs -0.086). A similar improvement was also noted for Total RVUs (546 vs 316). In other words, EHR users likely realized an increase in patients per hour and productivity when compared to the paper-based physician offices.

Study Closure:

Subject study was closed with Conemaugh IRB on April 2, 2012. Final report and supporting documents were delivered to USAMRMC ORP HRPO and found to be acceptable on April 19, 2012 (refer to Appendix B).

***Subtask 1.2*** Enhance the service-based HIE infrastructure and services to support further exchange of digital medical imaging information in a rural setting.

**** Task completed during previous periods****

***Subtask 1.3*** Research and evaluate the ability to electronically exchange digital images and how this functionality will affect the delivery of patient care within a rural health care system, to include an analysis on provider productivity, throughput, duplicative testing and continuity of care.

Study Closure:

This study has been completed and closed with Conemaugh IRB on July 14, 2011. Final report and supporting documents were delivered to USAMRMC ORP HRPO and found to be acceptable on August 29, 2011 (refer to Appendix C).

Manuscript:

A study manuscript was completed and submitted to Radiology on April 12, 2012. Unfortunately, CMMC received notification on May 10, 2012 that it was not accepted for publication. Reviewer comments have been discussed by the study team and minor edits are being completed in order to submit to Telemedicine and eHealth in July 2012. Please refer to Appendix D for a copy of the manuscript.

***Subtask 1.4*** Deploy (via portal technology) a pilot demonstration of the electronic exchange of private sector ambulatory medical records with the DoD and other selected stakeholders using test data.

**** Task completed during previous periods****

***Subtask 1.5*** Perform a technical feasibility study to focus on repurposing the BHIE-AHLTA web services toward the existing NHIN Federal Adapter for the purpose of standards based exchange of Military Health System data domains with private sector partners.

**** Task completed during previous periods****

***Subtask 1.6*** Begin development on a private sector version of the Federal Gateway/Adapter (work to be based on the code that is anticipated to be available from ONC) using interoperable HITSP standards to progress the goals of this national effort.

**** Task completed during previous periods****

***Subtask 1.7*** Perform an assessment of the volume of cases that Conemaugh physicians have with SSA regarding veteran/military disability claims and assess provider satisfaction with existing SSA process for information gathering and submission.

**** Task completed during previous periods****

## Arm 2: The Impact of Consumer Informatics in the Chronic Care Model: Metabolic Syndrome and Gestational Diabetes in a Rural Setting (A-15835.1).

This arm focuses on finding innovative solutions to slow down the growing epidemic of metabolic syndrome in the United States using consumer informatics. A personal health record (PHR) is offered to enrolled randomized subjects for six months. Subjects are able to create a PHR and communicate electronically with their physician and staff members. A total of five physician practices have participated in the study with the recent addition of a gestational diabetes group. Changes in clinical outcome measures are compared to a control group, consisting of study specific enrolled, randomized subjects. In addition, qualitative data is being assessed through a survey instrument and PHR usage data is collected to make sound study conclusions.

***Subtask 2.1*** Deploy HIE tools for patient and community outreach in varied rural environments.

Subject recruitment for the respective study has been challenging. Interest has been greatest from patients deriving from suburban physician offices whereas anecdotal concerns persist regarding Internet access and an elderly population in rural communities. Patients and providers, from our multi-year experience, are clearly not interested and ready for personal health records as a tool in managing healthcare matters. Our experience directly aligns with national adoption rates and attitudes towards PHR's.

| MIDHT PHR Enrollment Summary | | |
|---|---|---|
| **Description** | **Reporting Period** | **Total to Date** |
| **Inquiries** | **84** | **195** |
| **Screenings** | **41** | **79** |
| **Screen Failures** | **4** | **9** |
| **Enrolled (Metabolic Syndrome)** | **33** | **64** |
| **Enrolled (Gestational Diabetes)** | **5** | **5** |
| **Withdrawals** | **5** | **11** |
| ***Active*** | ***25*** | |
| **Completed** | **14** | **33** |

**Table 5. Summary Enrollment.**

The opportunity to create secure, online personal health records and send electronic messages to providers through RelayHealth has not been well received by patients. Recruitment challenges align with low adoption of said technology nationwide. The California Healthcare Foundation reports that only 7% of U.S. adults use some sort of PHR, with 51% of access offered by their health insurance plan (1). In addition, consumers in rural areas have known issues with access to the Internet, low self-awareness of their health conditions and an elderly population that is hesitant with technology adoption. Finally, consumers have stated concerns with putting their health information online due to theft and privacy invasion.

In order to assess patient interest in the study, CMMC staff has used various recruiting strategies during the past year, including:

- Direct patient letters
- Advertisements in numerous newspapers
- Facebook postings
- Flyers and posterboards in participating physician offices
- Phone On Hold messages
- Global emails
- Face-to-face meetings with physicians
- Health Fairs
- Metabolic Syndrome lectures

Enrollment has closed for the metabolic syndrome arm to allow time for subjects to complete the intervention, data analysis and write-up of results before contract termination.

Enrollment remains open for the gestational diabetes arm until the end of July 2012.

***Subtask 2.2*** Research and evaluate the impact of a personal health record (PHR) on provider(s) and consumer(s) with particular focus on chronic disease prevention.

Core online PHR functionality includes:

- Request Appointments
- Request Prescription Renewals
- Request Lab and Test Results
- Note to Doctor
- Note to Office
- Access to education materials
- webVisit®

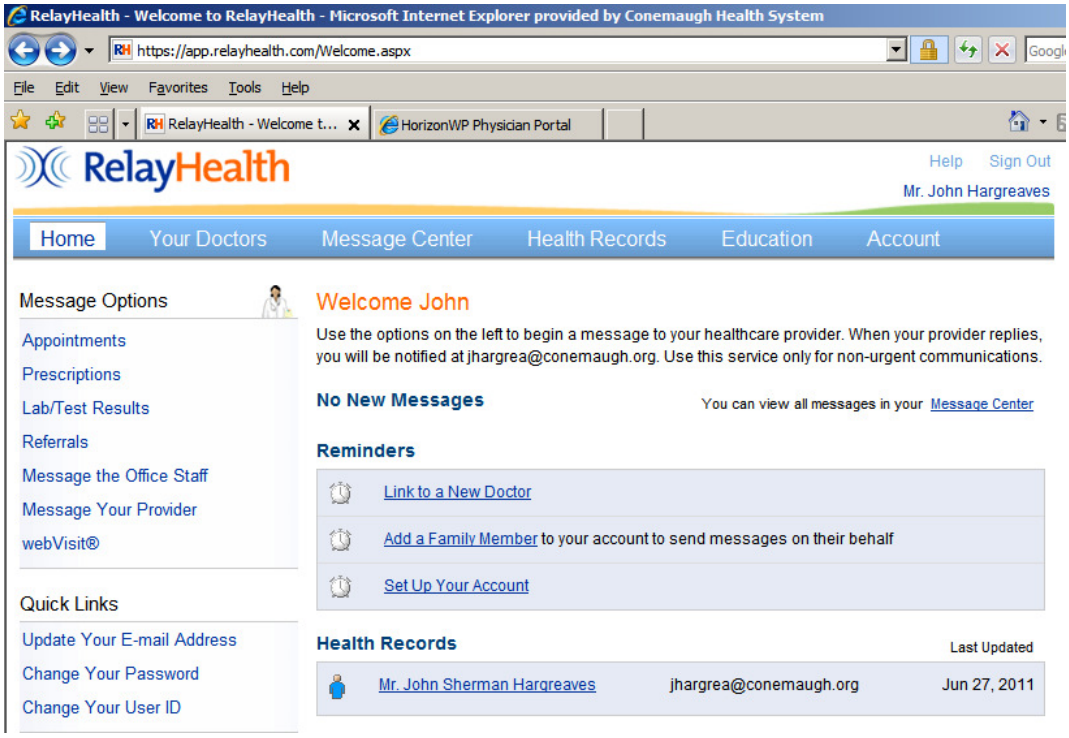


**Figure 1. Relay Health PHR.**

It is important to note that some participating physicians have been resistant to responding to subject messages through RelayHealth as reflected by qualitative feedback from subjects. This finding is not surprising as physician perception of PHR's are likely to vary from total abhorrence to complete support. Physicians have stated concerns with the accuracy and privacy of PHRs and have expressed doubts that patients will take the time to create PHRs and keep them updated (2).

The following graph shows subject usage of specific PHR message types (initiated by patient). Subjects prefer the Rx refill requests, request lab/test results, and "Note to Doctor" functionality whereas requesting appointments and webVisits are used less frequently. A total of six (6) subjects have not "linked" to their doctors to date and are unable to send messages. All subjects are provided with written instructions on how to setup accounts and link to their doctor.

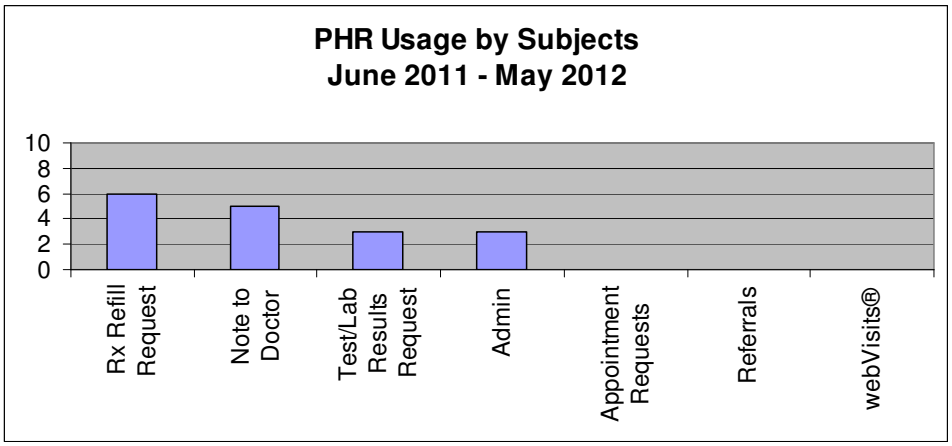


**Figure 2. Subject PHR Usage.**

***Subtask 2.3*** Research and evaluate the impact of web-based secure messaging, online consultations, prescription renewals, and appointment scheduling on consumer awareness and their ability to effectively self manage their health compared to those consumers not using a PHR.

Statistical analysis of health outcome measures for the PHR Group and Control Group will be completed before contract termination. Subject outcome measures include blood pressure, waist circumference, weight, body mass index (BMI), body fat, HDL cholesterol, triglycerides, glucose and hemoglobin A1c.

## KEY RESEARCH ACCOMPLISHMENTS

- Completion and closure of study A – 15835.2
- Completion and closure of study A – 16192.1
- Enrolled 37 subjects for study A –15835.1

## REPORTABLE OUTCOMES

- Conemaugh presented research update to Dr. Steve Steffensen and Betty Levine during local site visit in Johnstown, PA on June 9, 2011
- Manuscript submitted to Radiology on April 12, 2012 ; not accepted for publication
- 8th Annual Conemaugh Research Poster Symposium (March 26-30, 2012)

## CONCLUSION

The EHR study and PACS study have both been completed. Final documents were submitted to Conemaugh and U.S. Army Institutional Review Boards (IRB) and found to be acceptable. A manuscript detailing the PACS study was submitted to Radiology but not accepted for publication.

PHR's have generated minimal interest and usage by subjects and providers alike. Our findings align with patient attitudes nationwide. Adoption of said technology remains below 10% and significant usage can only be found in geographic pockets or within specific patient populations. As the nation focuses on "meaningful use" of EHR systems, wide-spread adoption of PHRs may be 5-10 years away from reality (3).

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2. Witry MJ, Doucette WR, Daly JM, Levy BT, Chrischilles EA. Family Physician Perceptions of Personal Health Records. *Perspect Health Inf Manag*. 2010 Jan 1;7:1d.

3. Hargreaves JS. Will Electronic Personal Health Records Benefit Providers and Patients in Rural America? *Telemed and e-Health*. March 2010, 16(2): 167-176.

## APPENDICES

**Appendix 1 - Electronic Health Record (EHR) Implementation Survey**

| 1. The instructions and prompts are helpful. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Never | 12.0% | 3 |
| Sometimes | 52.0% | 13 |
| Occasionally | 4.0% | 1 |
| Most of the time | 28.0% | 7 |
| Always | 4.0% | 1 |
| *answered question* | | 25 |
| *skipped question* | | 1 |

| 2. Getting paper-based documents in and out of the system is easy. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Never | 3.8% | 1 |
| Sometimes | 19.2% | 5 |
| Occasionally | 19.2% | 5 |
| Most of the time | 50.0% | 13 |
| Always | 7.7% | 2 |
| *answered question* | | 26 |
| *skipped question* | | 0 |

| 3. I sometimes wonder if I'm using the right command. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Never | 15.4% | 4 |
| Sometimes | 30.8% | 8 |
| Occasionally | 34.6% | 9 |
| Most of the time | 19.2% | 5 |
| Always | 0.0% | 0 |
| *answered question* | | 26 |
| *skipped question* | | 0 |

| 4. The speed of the EHR is fast enough to accomplish tasks. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Agree | 42.3% | 11 |
| Disagree | 53.8% | 14 |
| Not Sure | 3.8% | 1 |
| *answered question* | | 26 |
| *skipped question* | | 0 |

| 5. This software seems to disrupt the way I normally like to arrange my work. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Agree | 50.0% | 13 |
| Disagree | 38.5% | 10 |
| Not Sure | 11.5% | 3 |
| | ***answered question*** | **26** |
| | ***skipped question*** | **0** |

| 6. The organization of the menus or information lists seems quite logical. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Agree | 50.0% | 13 |
| Disagree | 50.0% | 13 |
| Not Sure | 0.0% | 0 |
| | ***answered question*** | **26** |
| | ***skipped question*** | **0** |

| 7. It is relatively easy to move from one part of a task to another. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Agree | 34.6% | 9 |
| Disagree | 57.7% | 15 |
| Not Sure | 7.7% | 2 |
| | ***answered question*** | **26** |
| | ***skipped question*** | **0** |

| 8. It is easy to forget how to do things with the EHR. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Agree | 34.6% | 9 |
| Disagree | 53.8% | 14 |
| Not Sure | 11.5% | 3 |
| | ***answered question*** | **26** |
| | ***skipped question*** | **0** |

| 9. The EHR occasionally performs in a way which can't be logically understood. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| True | 69.2% | 18 |
| False | 30.8% | 8 |
| | ***answered question*** | **26** |
| | ***skipped question*** | **0** |

| 10. I have to seek assistance most times when I use the EHR. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| True | 16.0% | 4 |
| False | 84.0% | 21 |
| | ***answered question*** | **25** |
| | ***skipped question*** | **1** |

| 11. How often can you count on the EHR to be up and available. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Never | 0.0% | 0 |
| Sometimes | 3.8% | 1 |
| Occasionally | 3.8% | 1 |
| Most of the time | 73.1% | 19 |
| Always | 19.2% | 5 |
| | ***answered question*** | **26** |
| | ***skipped question*** | **0** |

| 12. How often is the EHR subject to frequent problems and crashes. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Never | 7.7% | 2 |
| Sometimes | 23.1% | 6 |
| Occasionally | 69.2% | 18 |
| Most of the time | 0.0% | 0 |
| Always | 0.0% | 0 |
| | ***answered question*** | **26** |
| | ***skipped question*** | **0** |

| 13. The EHR provides me with all the information I need to take care of the patient. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Never | 0.0% | 0 |
| Sometimes | 23.1% | 6 |
| Occasionally | 7.7% | 2 |
| Most of the time | 61.5% | 16 |
| Always | 7.7% | 2 |
| | ***answered question*** | **26** |
| | ***skipped question*** | **0** |

**14. The EHR screens include a lot of extra information that I don't need.**

| Answer Options | Response Percent | Response Count |
|---|---|---|
| Agree | 19.2% | 5 |
| Disagree | 65.4% | 17 |
| Not Sure | 15.4% | 4 |
| *answered question* | | 26 |
| *skipped question* | | 0 |

**15. There is inaccurate information in the EHR.**

| Answer Options | Response Percent | Response Count |
|---|---|---|
| Never | 16.0% | 4 |
| Sometimes | 64.0% | 16 |
| Occasionally | 16.0% | 4 |
| Most of the time | 4.0% | 1 |
| Always | 0.0% | 0 |
| *answered question* | | 25 |
| *skipped question* | | 1 |

**16. The EHR provides information that is up-to-date.**

| Answer Options | Response Percent | Response Count |
|---|---|---|
| Never | 0.0% | 0 |
| Sometimes | 11.5% | 3 |
| Occasionally | 3.8% | 1 |
| Most of the time | 76.9% | 20 |
| Always | 7.7% | 2 |
| *answered question* | | 26 |
| *skipped question* | | 0 |

**17. The system lets me quickly find the information I need.**

| Answer Options | Response Percent | Response Count |
|---|---|---|
| Never | 0.0% | 0 |
| Sometimes | 40.0% | 10 |
| Occasionally | 28.0% | 7 |
| Most of the time | 24.0% | 6 |
| Always | 8.0% | 2 |
| *answered question* | | 25 |
| *skipped question* | | 1 |

| 18. The information in the EHR is presented in a useful format. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Yes | 30.8% | 8 |
| No | 15.4% | 4 |
| Depends on specific functionality | 53.8% | 14 |
| | ***answered question*** | **26** |
| | ***skipped question*** | **0** |

| 19. The information in the system includes the level of detail that I need. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Yes | 42.3% | 11 |
| No | 15.4% | 4 |
| Depends on specific functionality | 42.3% | 11 |
| | ***answered question*** | **26** |
| | ***skipped question*** | **0** |

**20. Compared to previous routines, how has the EHR changed the performance of the following tasks?**

| Answer Options | Much More Difficult | Slightly More Difficult | No Change | Slightly Easier | Much Easier | N/A, Don't Know | Response Count |
|---|---|---|---|---|---|---|---|
| Documenting physical exams | 3 | 6 | 1 | 1 | 4 | 11 | 26 |
| Documenting histories | 4 | 5 | 1 | 1 | 5 | 10 | 26 |
| Documenting allergies | 1 | 2 | 4 | 2 | 7 | 9 | 25 |
| Documenting CPT and ICD-9 codes for billing purposes | 2 | 0 | 3 | 3 | 4 | 14 | 26 |
| Keeping problem lists updated | 2 | 3 | 2 | 6 | 6 | 7 | 26 |
| Keeping medication lists updated | 3 | 4 | 3 | 2 | 6 | 8 | 26 |
| Ordering laboratory and radiology tests | 6 | 2 | 1 | 2 | 3 | 12 | 26 |
| Reviewing laboratory and radiology results | 2 | 2 | 3 | 5 | 7 | 7 | 26 |
| Writing prescriptions | 2 | 3 | 1 | 3 | 7 | 10 | 26 |
| Renewing prescriptions | 2 | 1 | 3 | 3 | 9 | 8 | 26 |
| Monitoring medication safety during prescribing | 1 | 1 | 1 | 5 | 4 | 14 | 26 |
| Monitoring patient medication adherence | 1 | 0 | 4 | 2 | 3 | 16 | 26 |
| Communicating referral information to specialists | 2 | 0 | 4 | 7 | 2 | 11 | 26 |
| Reviewing referral information from specialists | 1 | 1 | 9 | 5 | 2 | 8 | 26 |
| Ordering appropriate preventive care services | 1 | 4 | 3 | 3 | 2 | 13 | 26 |
| Making a list of patients based on diagnosis or history | 1 | 0 | 0 | 3 | 1 | 21 | 26 |
| Contacting patients to remind them of appointments | 0 | 0 | 4 | 2 | 2 | 18 | 26 |
| Assisting patients in self-management activities | 1 | 1 | 2 | 2 | 2 | 18 | 26 |
| | | | | | | *answered question* | **26** |

**21. How strongly do you agree or disagree with the following statements regarding the EHR?**

| Answer Options | Completely Agree | Generally Agree | Generally Disagree | Completely Disagree | Don't Know | N/A | Response Count |
|---|---|---|---|---|---|---|---|
| Using the EHR has enabled me to accomplish tasks quicker | 2 | 11 | 9 | 4 | 0 | 0 | 26 |
| I work longer hours to see the same number of patients | 8 | 4 | 4 | 4 | 2 | 4 | 26 |
| Using the EHR has enhanced my effectiveness in my job | 2 | 12 | 8 | 4 | 0 | 0 | 26 |
| Using the EHR has made it easier to do my job | 3 | 11 | 8 | 4 | 0 | 0 | 26 |
| I find the EHR useful in my job | 2 | 16 | 5 | 2 | 1 | 0 | 26 |
| Learning to operate the EHR has been easy for me | 1 | 15 | 8 | 2 | 0 | 0 | 26 |
| I have become skilled at using the advanced features | 2 | 12 | 5 | 0 | 4 | 3 | 26 |
| Easier to access patient information from outside the office | 2 | 5 | 1 | 0 | 3 | 15 | 26 |
| There are too many alerts and reminders | 3 | 7 | 3 | 1 | 4 | 8 | 26 |
| Has decreased the amount of time I spend talking to patients | 4 | 6 | 7 | 2 | 3 | 4 | 26 |
| Helps me adhere to clinical practice guidelines | 1 | 7 | 2 | 0 | 6 | 10 | 26 |
| Using an EHR has caused disruptions to my work flow | 4 | 8 | 8 | 3 | 1 | 2 | 26 |
| Has improved my ability to make decisions about patient care | 1 | 6 | 4 | 1 | 3 | 10 | 25 |
| Has improved my ability to provide preventive care | 1 | 6 | 3 | 2 | 4 | 10 | 26 |
| I can better monitor how many of my patients are receiving appropriate care | 1 | 4 | 5 | 1 | 2 | 13 | 26 |
| Benefits of adopting an EHR have outweighed the challenges | 2 | 10 | 5 | 3 | 4 | 2 | 26 |
| | | | | | | *answered question* | **26** |

| 22. Would you recommend EHRs to other providers interested in adopting health information technology? | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Yes | 72.0% | 18 |
| No | 28.0% | 7 |
| *answered question* | | **25** |
| *skipped question* | | **1** |

| 23. If you could change one thing about the Allscripts EHR system, what would it be? | |
|---|---|
| **Answer Options** | **Response Count** |
| | 18 |
| *answered question* | **18** |
| *skipped question* | **8** |

| 24. What has been the most positive benefit of using an EHR? | |
|---|---|
| **Answer Options** | **Response Count** |
| | 18 |
| *answered question* | **18** |
| *skipped question* | **8** |

| 25. How often do you print out a Visit Summary report from the EHR system for your patient at the conclusion of the patient visit? | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Always | 0.0% | 0 |
| Sometimes | 20.0% | 5 |
| Never | 44.0% | 11 |
| Don't know | 12.0% | 3 |
| Not Applicable | 24.0% | 6 |
| *answered question* | | **25** |
| *skipped question* | | **1** |

| 26. How long have you been using the Allscripts EHR at your practice? | |
|---|---|
| **Answer Options** | **Response Count** |
| | 26 |
| *answered question* | **26** |
| *skipped question* | **0** |

**27. How would you classify your level of comfort with general computer technology (e.g. email, Internet, word processing)?**

| Answer Options | Response Percent | Response Count |
|---|---|---|
| Very comfortable | 53.8% | 14 |
| Somewhat comfortable | 46.2% | 12 |
| Not very comfortable | 0.0% | 0 |
| *answered question* | | 26 |
| *skipped question* | | 0 |

**28. Please choose the statement that best describes the training you received for your current EHR.**

| Answer Options | Response Percent | Response Count |
|---|---|---|
| I have received no training and I'm learning the system as I use it | 0.0% | 0 |
| Informal training by practice staff when time permitted | 3.8% | 1 |
| Less than ten hours dedicated to formal training (with vendor or practice trainers) | 53.8% | 14 |
| Ten or more hours dedicated to formal training (with vendor or practice trainers) | 42.3% | 11 |
| *answered question* | | 26 |
| *skipped question* | | 0 |

**29. What is your title?**

| Answer Options | Response Percent | Response Count |
|---|---|---|
| Clerical | 37.5% | 9 |
| Nurse | 33.3% | 8 |
| Office Manager | 4.2% | 1 |
| Physician | 8.3% | 2 |
| Physician Assistant | 0.0% | 0 |
| Other | 16.7% | 4 |
| *answered question* | | 24 |
| *skipped question* | | 2 |

**30. Do you have any previous EHR experience?**

| Answer Options | Response Percent | Response Count |
|---|---|---|
| Yes | 26.9% | 7 |
| No | 73.1% | 19 |
| *answered question* | | 26 |
| *skipped question* | | 0 |

| 31. How satisfied are you with the EHR system? | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Very Dissatisfied | 11.5% | 3 |
| Dissatisfied | 23.1% | 6 |
| Neutral | 30.8% | 8 |
| Somewhat Satisfied | 30.8% | 8 |
| Very Satisfied | 3.8% | 1 |
| | ***answered question*** | **26** |
| | ***skipped question*** | **0** |

| 32. Please provide additional comments as needed. | |
|---|---|
| **Answer Options** | **Response Count** |
| | 6 |
| ***answered question*** | **6** |
| ***skipped question*** | **20** |

**Appendix 2 – Protocol Closure Memorandum**



**John Hargreaves**

**From:** Brosch, Laura R Dr CIV USA MEDCOM USAMRMC [Laura.Brosch@us.army.mil]
**Sent:** Thursday, April 19, 2012 2:16 PM
**To:** Brian Lieb
**Cc:** Richard Wozniak; Bennett, Jodi H Ms CIV USA MEDCOM USAMRMC; 'Stephenson, Jeffrey Dr IBA'; 'betty.levine@tatrc.org'; Bane, Elena G Ms CIV USA MEDCOM USAMRAA; John Hargreaves; Duchesneau, Caryn L Ms CIV USA MEDCOM USAMRMC; Katopol, Kristen R Ms CTR US USA MEDCOM USAMRMC; Englar, Nancy E CTR US USA MEDCOM USAMRMC; Drayton, Maria Ms CTR US USA MEDCOM USAMRMC; Brosch, Laura R Dr CIV USA MEDCOM USAMRMC
**Subject:** A-15835.2, Protocol Closure Memorandum (Proposal Log Number 09064002, Award Number W81XWH-09-2-0061) (UNCLASSIFIED)

Classification: **UNCLASSIFIED**
Caveats: NONE

SUBJECT: Project Completion for the Protocol, "Military Interoperable Digital Hospital Testbed (MIDHT) Year 2 Arm 1: Longitudinal Study for the Use of Ambulatory Electronic Health Records (EHR) in Rural Communities," Submitted by Brian Lieb, DO, Conemaugh Valley Memorial Hospital, Carrolltown, Pennsylvania, in Support of the Proposal, "Military Interoperable Digital Hospital Testbed (MIDHT), Submitted by Richard S. Wozniak, MD, Memorial Medical Center, Johnstown, Pennsylvania, Proposal Log Number 09064002, Award Number W81XWH-09-2-0061, HRPO Log Number A-15835.2

1. A final report was received by the U.S. Army Medical Research and Materiel Command (USAMRMC), Office of Research Protections (ORP), Human Research Protection Office (HRPO) on 12 April 2012. This no greater than minimal risk study was initially approved by the HRPO on 18 May 2010.

2. The Conemaugh Memorial Medical Center Institutional Review Board documentation acknowledging closure of this protocol, dated 2 April 2012, was received by the USAMRMC ORP HRPO on 12 April 2012. The final report and supporting documents were reviewed and found to be acceptable.

3. No further review of the protocol will be conducted, and the HRPO protocol file will be closed.

4. The HRPO point of contact for this study is Nancy Englar, MHL, BSN, RN, Human Subjects Protection Scientist, 301-619-2242/nancy.e.englar.ctr@us.army.mil.

LAURA R. BROSCH, PhD
Director, Office of Research Protections
Director, Human Research Protection Office
U.S. Army Medical Research and Materiel Command

Note: The official copy of this closure memo is housed with the protocol file at the Office of Research Protections, Human Research Protection Office, 504 Scott Street, Fort Detrick, MD 21702. Signed copies will be provided upon request.

Classification: **UNCLASSIFIED**
Caveats: NONE

6/19/2012

**Appendix 3 – Protocol Closure Memorandum**



**John Hargreaves**

**From:** Duchesneau, Caryn L Ms CIV USA MEDCOM USAMRMC [Caryn.Duchesneau@us.army.mil]
**Sent:** Monday, August 29, 2011 5:03 PM
**To:** Richard Wozniak
**Cc:** John Hargreaves; Bennett, Jodi H Ms CIV USA MEDCOM USAMRMC; John Karduck; 'Stephenson, Jeffrey Dr IBA'; Jeanette Croner; Chris Smith; Thomas Simunich; Wendi Nagle; Bane, Elena G Ms CIV USA MEDCOM USAMRAA; 'steve.steffensen@tatrc.org'; Brosch, Laura R Dr CIV USA MEDCOM USAMRMC; Duchesneau, Caryn L Ms CIV USA MEDCOM USAMRMC; Katopol, Kristen R Ms CTR US USA MEDCOM USAMRMC; Eaton, Karen M Ms CTR US USA MEDCOM USAMRMC; Drayton, Maria Ms CTR US USA MEDCOM USAMRMC; Dyson, Nicole CIV US USA MEDCOM USAMRMC
**Subject:** A-16192.1, Protocol Closure Memorandum (Proposal Log Number 10322003, Award Number W81XWH-10-2-0180) (UNCLASSIFIED)

Classification: **UNCLASSIFIED**
Caveats: NONE

SUBJECT: Project Completion for the Protocol, "Military Interoperable Digital Hospital Testbed (MIDHT) Year 2, Arm 1: System-Wide Image Access: Analysis on Duplicate Testing in a Rural Healthcare Environment," Submitted by Richard S. Wozniak, MD, Memorial Medical Center, Johnstown, Pennsylvania, in Support of the Proposal, "Military Interoperable Digital Hospital Testbed (MIDHT)," Submitted by John Karduck, MD, Memorial Medical Center, Johnstown, Pennsylvania, Proposal Log Number 10322003, Award Number W81XWH-10-2-0180, HRPO Log Number A-16192.1

1. A final report and request to close the protocol was received by the U.S. Army Medical Research and Materiel Command (USAMRMC), Office of Research Protections, Human Research Protection Office (HRPO) on 27 July 2011. This no greater than minimal risk study was initially approved by the HRPO on 18 August 2010.

2. The Memorial Medical Center Institutional Review Board documentation acknowledging closure of this protocol, dated 14 July 2011, was received by the USAMRMC HRPO on 27 July 2011. The final report and supporting documents were reviewed and found to be acceptable.

3. No further review of the protocol will be conducted, and the HRPO protocol file will be closed.

4. The HRPO point of contact for this study is Karen M. Eaton, MS, Human Subjects Protection Scientist, at 301-619-9268/karen.m.eaton@us.army.mil.

CARYN L. DUCHESNEAU, CIP
Chief, Human Subjects Protection Review
Human Research Protection Office
Office of Research Protections
U.S. Army Medical Research and Materiel Command

Note: The official copy of this closure memo is housed with the protocol file at the Office of Research Protections, Human Research Protection Office, 504 Scott Street, Fort Detrick, MD 21702. Signed copies will be provided upon request.

Classification: **UNCLASSIFIED**
Caveats: NONE

8/30/2011

**Appendix 4 – PACS Manuscript**

# Full Title Page

Richard S. Wozniak, MD, John S. Hargreaves, MBA, Thomas J. Simunich, MBA, MS in MIS, Lisa Pasierb, Ph.D, Jeanette R. Croner, MHA.

Conemaugh Memorial Medical Center
1086 Franklin Street
Johnstown, Pennsylvania 15905

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***The Impact of System-Wide Image Access on Duplicate Testing in a Rural Healthcare System.***

This paper has not been presented at an RSNA meeting and has not been accepted for presentation at a future meeting.

Type of manuscript: Original Research

Word Count: 2,088

Address for Correspondence: Richard Wozniak, MD
Conemaugh Memorial Medical Center
1086 Franklin Street
Johnstown, PA 15905

Funding: This work was supported by the U.S. Army Medical Research and Materiel Command under Contract No. W81XWH-09-2-0061.

# Abbreviated Title Page

a) The Impact of System-Wide Image Access on Duplicate Testing in a Rural Healthcare System.

b) Original Research

c) Advance in Knowledge

1. The ability for the receiving institution to view images taken off-site through a picture archiving and communications system (PACS) resulted in a 7% reduction in duplicate chest x-ray and CT scan (head) testing from 0-7 days when compared to a pre PACS implementation period.
2. As surveyed, seventy percent of physicians positively stated that immediate image access did reduce the number of exams reordered.

d) Implications for Patient Care

1. System-wide availability of images will have a positive impact and may reduce unnecessary imaging at the receiving institution. Benefits will also transfer to patients as health risks associated with radiation exposure will decrease.
2. Implementers should have a solid plan in place to communicate and train users on the new functionality. Leadership should expect that change management will vary amongst physicians and may impact immediate results.

e) Summary Statement

The implementation of picture archiving and communications system (PACS) throughout a rural health care system will have positive benefits both to patients and the institutions involved and likely reduce unnecessary imaging, operating costs and radiation exposure to patients.

# Abstract

**Purpose:**
To test the hypothesis that duplicate imaging will decrease among transfer patients to a tertiary care center from two rural off-site hospitals after the implementation of picture archive and communications system (PACS) at the off-sites.

**Materials and Methods:**
This minimal risk, HIPAA-compliant study was approved by Conemaugh's Institutional Review Board (IRB), with waiver for informed consent for retrospective review of medical records. Using a master patient index (MPI), 625 duplicate chest x-rays and CT scans of the head between sending and receiving institution (taken within 0-7 days) were collected from July 2008 to June 2010. The study design utilized a pre vs. post quantitative methodology, with time periods based upon the extension of PACS technology to off-site locations. Additionally, qualitative feedback was gathered from physicians (n=76) using a survey tool to assess the impact of immediate image access and to quantify the number of off-site studies viewed by physicians (n=70) with PACS access.

**Results:**
A Chi-Square test of independence applied to either Days between date of service or aggregated Days between date of service over time period did not yield a statistically significant result despite a 7% reduction in duplicate imaging (hypothesis not accepted). A financial analysis of the resulting seven percent reduction in duplicate tests suggests a savings of $187,075 to patients and/or insurance companies.

**Conclusion:**

Extension of PACS technology to referring institutions is beneficial; however, realization of a significant reduction in duplicate testing will depend upon full support of ordering physicians, proper training, and effective communication.

# Introduction

The United States spends more on health care than any other country with an annual average of $6,401 per person, which is 2.4 times the average of developed countries (1). As hospital reimbursement becomes more challenging, health information technology (HIT) may offer solutions to achieve organization-wide cost savings. Duplicate testing is not only a well-known source of extraneous health care expenses but may also pose additional radiation risks to patients. As a rural health care system with multiple referring hospitals, how can efficiency and patient safety improve through coordinated care?

Duplicate testing remains an industry-wide challenge that must be addressed in order for health care reform to be realized. Haley et al found that 53% of transferred trauma patients had some portion of their images duplicated; resulting in $650,000 in additional costs (2). Thomas et al presented similar findings in that 43% of patients had computed topography (CT) scans repeated during facility transfers (3).

Recent studies have stressed the inherent risk to patients due to increased source of radiation exposure. Brenner and Hall state that 62 million CT scans are performed annually in the United States and involve larger radiation doses than more conventional x-ray tests (4). Berrington de Gonzalez et al also provide support for increased cancer risk estimating that 29,000 future cancers could be related to CT scans (5). Sodickson et al recommend the quantity of imaging should be monitored over time to ensure minimization of radiation exposure (6).

One solution that may reduce unnecessary radiology testing and reduce radiation exposure between central and remote sites is called Picture Archiving and Communication System (PACS). PACS are computer networks dedicated to the storage, retrieval, and presentation of images produced by medical imaging devices. PACS replaces film archives, allowing imaging access simultaneously and from off-site locations. PACS is commonly believed to reduce the number of unnecessary duplicate imaging tests ordered because of originals being lost or stored at a remote location. Past research suggests an individualized evaluation of PACS technology where incidence of duplicate testing may be high (7). Institutions involved with the transfer of patients may have the most to gain through this process.

## Materials & Methods

This study, located within the Conemaugh Health System (CHS), analyzed the impact of extending PACS to two remote hospitals stretched over a two county area in southwestern Pennsylvania. Conemaugh Memorial Medical Center (central site), located in Johnstown, Pennsylvania, is a tertiary care regional referral hospital known for clinical excellence and patient satisfaction. The level 1 trauma center located at the central site is one of just eleven centers in Pennsylvania. Miners Medical Center (remote site 1) is a 30-bed community satellite hospital located 45 minutes to the north of Johnstown whereas Meyersdale Medical Center (remote site 2) is a 20-bed Critical Care Access hospital located 60 minutes to the south of Johnstown. The study was approved by Conemaugh's Institutional Review Board (IRB), which included a waiver of informed consent for retrospective review of medical records and a minimal risk designation.

*Implementation*

Conemaugh extended the McKesson PACS, Radiology Information System (RIS) and Dolby Digital Dictation system used at the central site to the two remote facilities (Figure 1). This project allowed CHS to achieve consistency of radiology imaging, report management, and image access across the health system. PACS went live at the remote sites on July 1, 2009 (image transfer only). During the next six months, activities were completed to seamlessly integrate both the RIS and PACS systems for sharing of reports in production use.

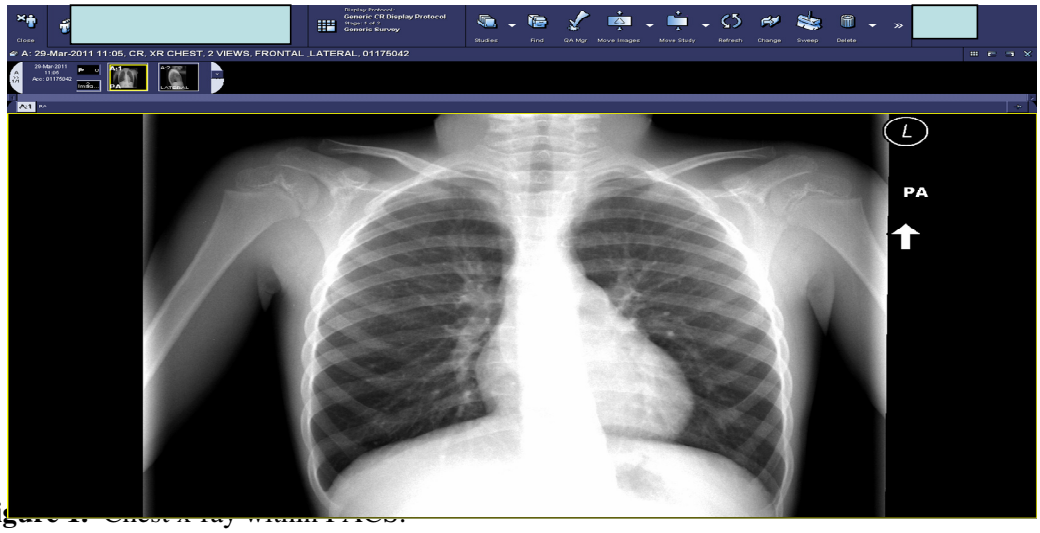


**Figure 1.** Chest X-ray within PACS.

*Study Design*

Both qualitative and quantitative methods were employed to investigate the study objectives and the hypothesis. Researchers hypothesized that the number of duplicated chest X-rays and CT scans (head) would significantly decrease after implementation of each phase of the PACS implementation compared to that of baseline.

Data collection primarily utilized historical data (retrospectively) to obtain the number of duplicated diagnostic imaging tests by evaluating empirical data retrieved from hospital financial

systems. The data was limited to patients that were first treated at one of the two remote sites and subsequently treated at the central site within the defined duplicate test time frame (0-7 days). This comparative analysis used a PRE (before PACS) and POST (after PACS) time period, see Table I, design to ascertain the expected change in the viewing of PACS images. The time periods were chosen with consideration for symmetry of data sets, stabilization of implementation, and the possibility of seasonality (time) as a covariate.

| **P R E** (baseline) | | **P O S T** | |
|---|---|---|---|
| | | ***Phase 1*** | ***Phase 2*** |
| ***2008*** | ***2009*** | | ***2010*** |
| **July** ***through*** **December** | **January** ***through*** **June** | **July** ***through*** **December.** | **January** ***through*** **June** |

**Table I.** Study Timeline.

Conemaugh MIS department provided duplicate test reports to the study team for analysis using the Master Patient Index (MPI) software. The report included chest x-rays (CPT 71010 and 71020) and CT scans of the head (CPT 70450) for the stated time periods. The report included data for patients that had the same test, as specified by the CPT codes above, and determined by the patient identifier, date of service, and service location. Inclusion of data was limited to studies repeated at the central site within 0-7 days. Time of service was used to include/exclude tests performed on the same date. Additional images completed at CMMC were removed from the analysis. Summary radiology volume data was also collected to assess the level of consistency of volume over time and thereby providing one measure of the homogeneity of the pre and post data sets.

In order to understand actual MMC physician usage of studies performed at the two rural hospitals, PACS User Reports were provided to the study team for analysis. The population included a randomized, proportionate sample of active physicians on the MMC medical staff. Reports were prepared for October - December 2009 and April - June 2010, which detailed viewing of studies that originated from the remote sites.

A physician opinion survey was also distributed to all applicable physicians on the MMC medical staff in traditional hard copy and online form. The survey was designed by Canada Health Infoway and was modified for use by Conemaugh with permission.[6] The survey was designed to gather qualitative feedback from physicians that use the system daily in their course of patient care. Survey objectives included assessing the impact of immediate image access to studies performed at two rural hospitals on productivity, decision-making, patient transfers, and duplicated exams.

## Results

A Chi-Square test of independence applied to either Days between (b/w) date of service (DOS) or aggregated Days b/w DOS over time period does not yield a statistically significant result despite a 7% reduction in duplicate imaging (hypothesis not accepted). However, a Chi-Square test of goodness-of-fit for aggregated Days b/w DOS using pre data as the expected (population) values and the post data as observed values does yield a statistically significant result at a family-wise alpha = 0.05. This result implies that the implementation of the PACS system at the remote sites did contribute to the change in the distribution of the count of duplicative testing (Figure 2). Furthermore, no statistical significance was found by CPT code or location (Figures 3-4).

Radiology volume data by CPT code for the remote sites is homogeneous between the pre and post data sets.

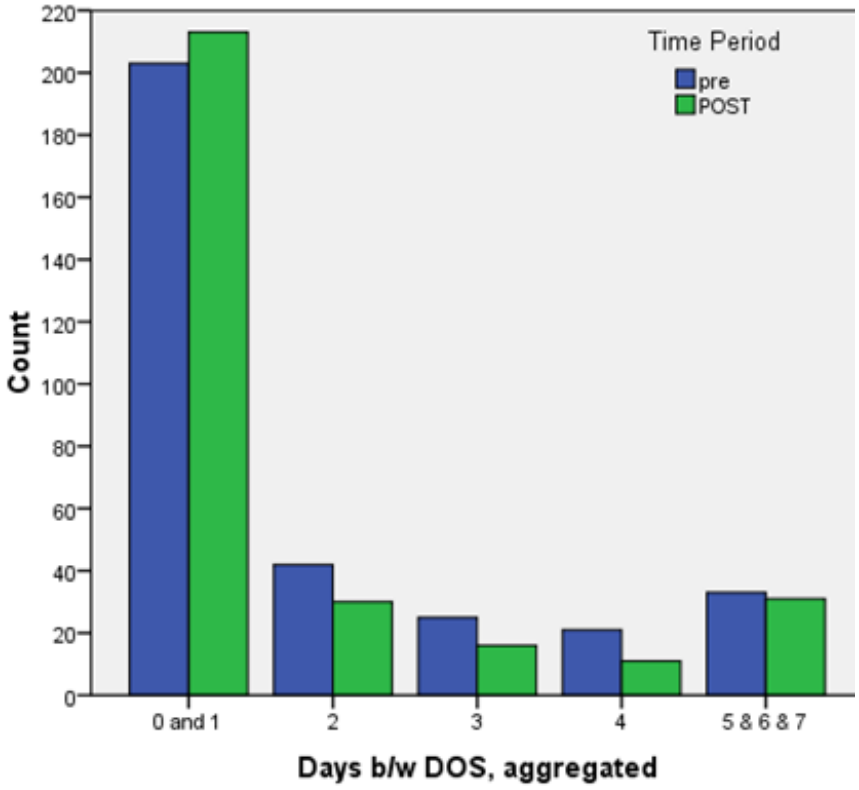


**Figure 2.** Duplicated Tests (PRE vs. POST) by Days Between Date of Service.

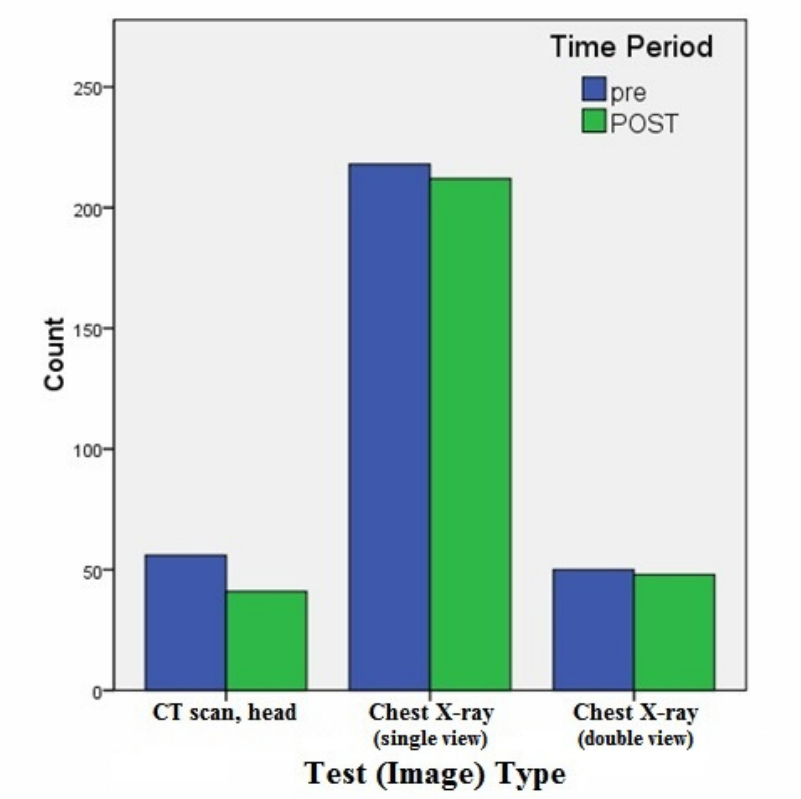


**Figure 3.** Duplicated Tests (PRE vs. POST) by CPT Code.

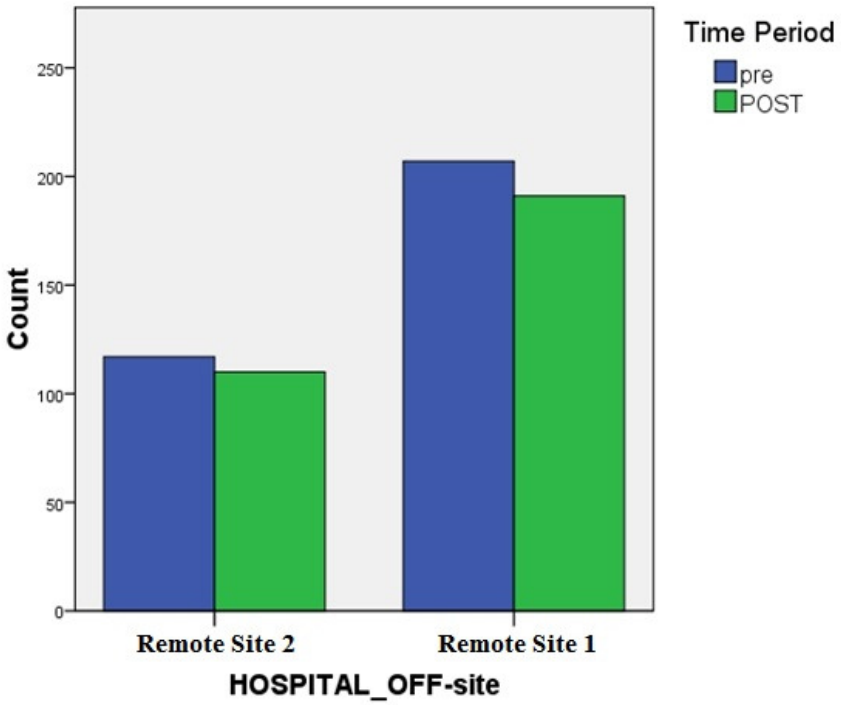


**Figure 4.** Duplicated Tests (PRE vs. POST) by Initial Location.

Despite non-significant findings in the reduction of duplicate testing, the financial analysis of the resulting seven percent reduction in duplicated chest x-rays and CT scans of the head suggests a savings of $187,075 to patients and/or insurance companies. As healthcare costs continue to climb and funding becomes more restricted, hospitals and health systems must consider implementing health information technologies to improve efficiencies and save money. Though not specifically addressed in this study, the reduction in duplicate testing will translate into less radiation exposure opportunities for patients transferred between facilities.

The following data was collected for a randomized, proportionate sample of 70 physicians with PACS access. As depicted below in Figure 5, the most active users of the PACS system in terms of viewing studies originating from MIMC and MYMC are Emergency Medicine (n=65) and Trauma (n=51) physicians. This result is expected as MMC is a tertiary care referral hospital with a Level 1 trauma center. The next grouping includes Otolaryngology (n=35), Urology (n=34), and Pulmonary (n=31). A third grouping includes General Surgery (n=28), Orthopedics (n=27) and Neurosurgery (n=26). The graph does not include an outlier for an orthopedic surgeon (n=581).

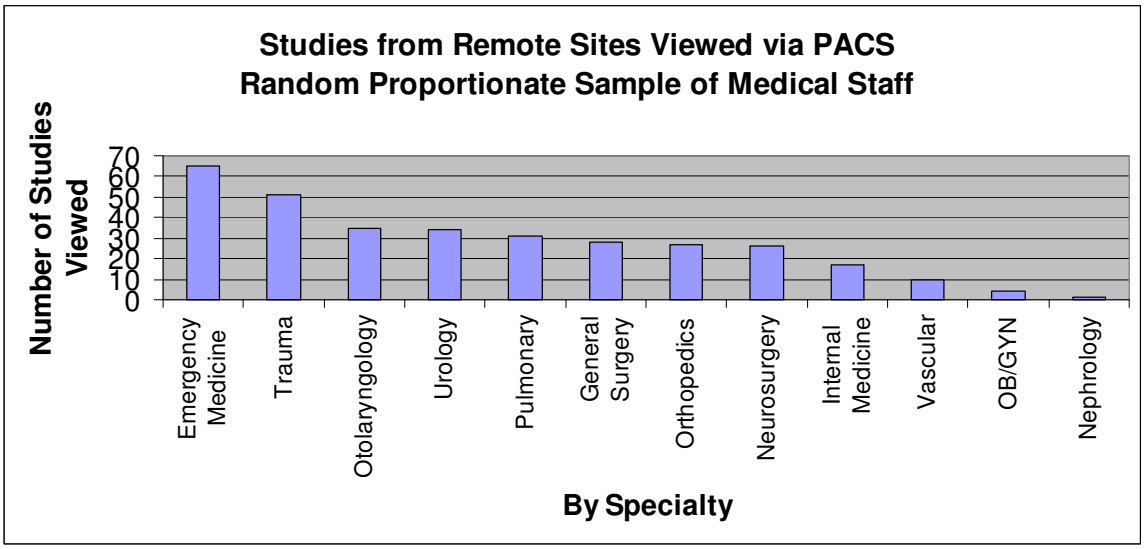


**Figure 5.** Number of studies performed off-site viewed using PACS.

Qualitative feedback from system users was collected via a survey tool. Seventy six physicians completed the survey during October 2010 through January 2011, representing approximately a 37% response rate. The following graph depicts self reported frequency of electronic access (Frequently, Sometimes, Seldom, or Never) of images originating from MIMC and MYMC by stated specialty. Results do align with empirical usage data for highest volume specialties: General Surgery, Trauma, Emergency Medicine, Internal Medicine, Orthopedics, Urology (not shown), Neurosurgery, Otolaryngology (not shown), and Pulmonary (not shown). Family practitioners responded the most but actual usage of the system is limited.

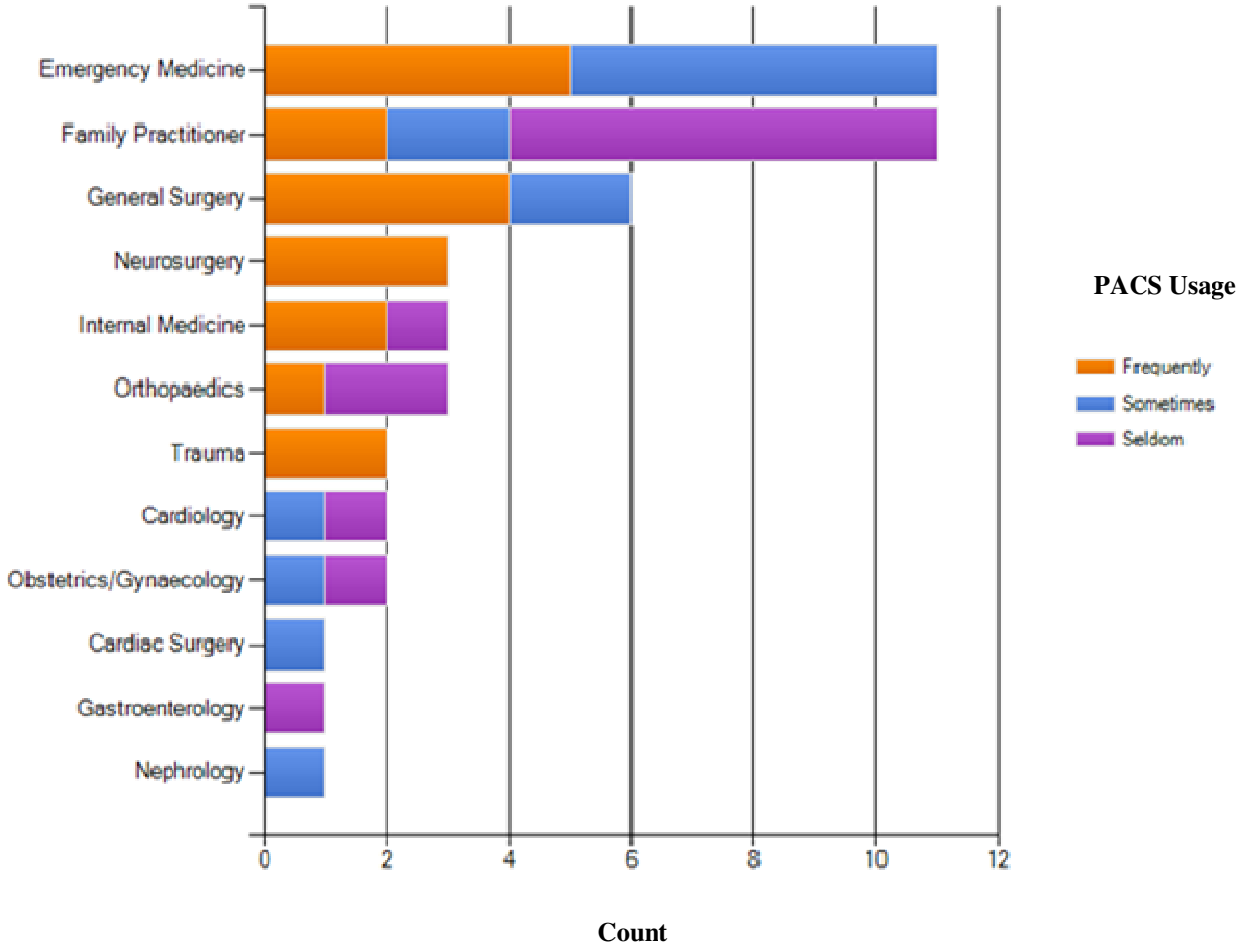


**Figure 6.** Survey Respondents by Specialty and Frequency of PACS Usage.

Surveys that indicated that the physician never used PACS to access images from the remote sites were removed from the dataset before analysis. The remaining responses (n=55) formed the dataset of analysis.

The most important survey question in terms of the hypothesis was Question 10a: Immediate PACS image access to films performed at Miners/Meyersdale has reduced the number of exams reordered because the images were not available when I needed them? Seventy percent (70%) of physicians that use the PACS system for this purpose either Strongly Agreed or Moderately

Agreed that the number of duplicated tests has been reduced post implementation whereas the remaining 30% disagreed or stated it was not applicable.

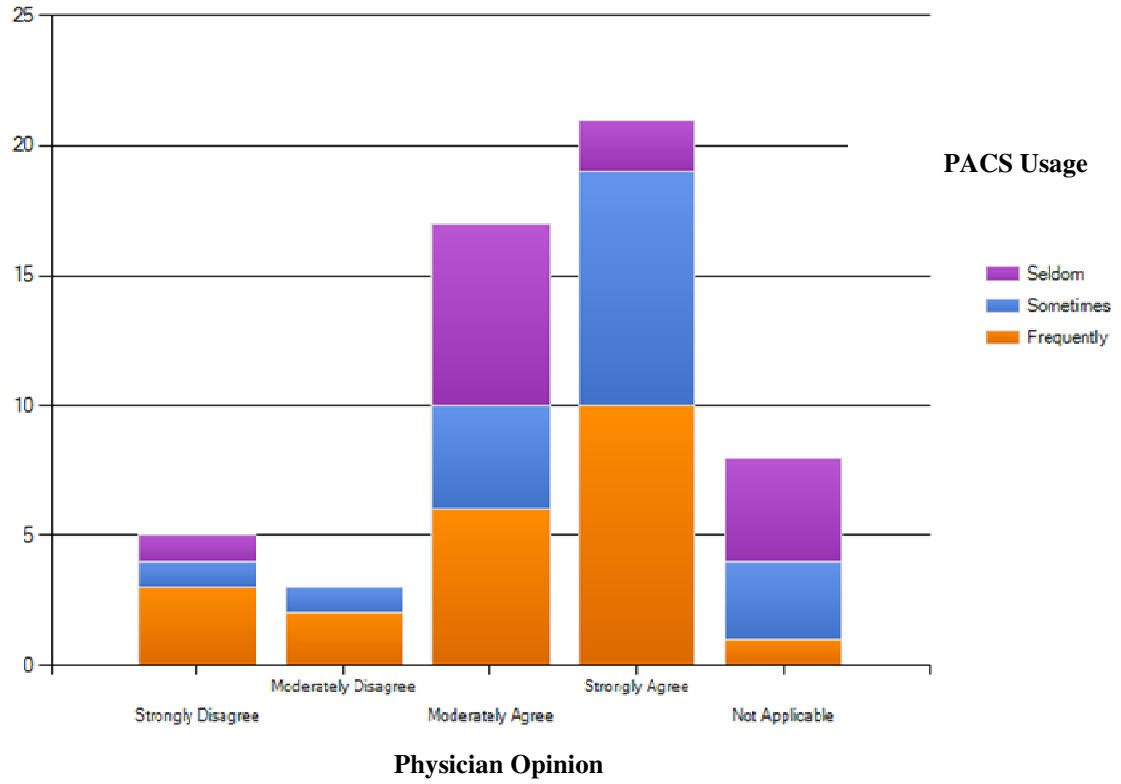


**Figure 7.** Self-reported Physician Opinion on Duplicate Testing by Frequency of PACS Usage.

Hypothesis testing of this question and others indicate that the response per category most probably represents a real difference in respondent opinion. The results of the hypothesis testing do not change for the aggregations of the responses of those questions. [Asymptotic significance at the 0.05 level is shown for all hypothesis testing.] Questions were analyzed using the original scale, a 5 level Likert scale, and an aggregation (collapsing) of that scale comprised of 3 levels (Agree, Disagree, N/A).

## Discussion

The implementation of PACS technology at smaller hospitals within the same health system is beneficial and likely to reduce costs and radiation exposure to patients. This study found that positive qualitative feedback and modest system usage by physicians did translate into a reduction in duplicate testing although not significant for patients receiving care from multiple facilities within the same rural health system. Despite new technologies being available, physicians must take the appropriate amount of time to receive education and attend training sessions. Unfortunately, some physicians may not change their ordering habits, which will reduce the expected benefit significantly depending on position and corresponding volume.

One limitation of the study is that the reason for ordering the test was not consistently collected and therefore unavailable for analysis by investigators. Such analysis would have been beneficial to determine how many more duplicate tests could have been prevented if the physician had been aware of the previous test conducted off-site or the test was re-ordered based upon sound clinical judgment.

To enhance data analysis and study conclusions, future research should attempt to collect reasoning information used in deciding to reorder an image. Given the surge in new technology investments nationwide from American Recovery and Reinvestment Act (ARRA) funding, future studies should be conducted on health information exchanges (HIE) that share images across the street or across state lines. An understanding of the cost benefit analysis of said HIE projects will be important to move the industry forward.

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